JPRS: 5863

14 December 1960

PROSPECTS FOR THE USE OF RADIOISOTOPES IN CZECHOSLOVAKIA

By K. Silink, S. Vohnout
and
O. Steinbach

Distributed by:

OFFICE OF TECHNICAL SERVICES
U. S. DEPARTMENT OF COMMERCE
WASHINGTON 25, D. C.

U. S. JOINT PUBLICATIONS RESEARCH SERVICE
1636 CONNECTICUT AVE., N. W.
WASHINGTON 25, D. C.

F O R E W O R D

This publication was prepared under contract by the UNITED STATES JOINT PUBLICATIONS RESEARCH SERVICE, a federal government organization established to service the translation and research needs of the various government departments.

JPRS: 5863

CSO: 4323-N/a

PROSPECTS FOR THE USE OF RADIOISOTOPES IN CZECHOSLOVAKIA
Departments for Work with Radioisotopes in the Health Service

/Following is a translation of an article by K. Silink and S. Vohnout entitled "Radioizotopove pracoviste ve zdravotnictvi" (English version above) in Ceskoslovenske Zdravotnictvi (Czechoslovakia Health Service), Vol. VIII No. 2-3, Prague, 1960, pages 124-130./

The use of radioactive isotopes is one of the great contributions of modern medical science to humanity. Atomic power directly applied serves the noble human purpose of diagnosing and treating diseases and curing the sick who could not be otherwise saved.

The development of methods for the application /of radioisotopes/ has significantly advanced all over the world. In Czechoslovakia we have had a long-standing tradition, linked to well known Czechoslovak radiology, of which the principal representatives between the two world wars were Ostrcil, Novak and Behounek. The Research Institute for Endocrinology /Vyzkumny Ustav endokrinologicky/ has been working since 1951 with artificial radioisotopes, notably the radioactive isotope I-131 to diagnose and treat diseases of the thyroid. Other methods of administering radioisotopes have been developed: among them are the radiosurgical method; the application of megadoses in treating advanced cases of cancer of the thyroid gland; and the methods of using radioisotopes in the treatment of certain heart conditions. Several other centers have been organized since, but their total potential is still inadequate to handle all cases. We are, therefore,concerned in creating conditions in which these methods could be used on a broad basis.

Cobalt and I-131 are the radioactive isotopes most frequently used in teletherapeutic instruments. According to the number of critical cases requiring treatment with these agents, we estimate the present minimum annual requirements to be 150-200 curies. We have actually

available only a few dozen curies and even these cannot be fully utilized because of the lack of technical facilities. We, therefore, cannot for the present save more than five to ten percent of the afflicted for whom the treatment with this isotope is of vital importance. A similar situation prevails in the application of radioactive phosphorus P-32 suitable for treatment of blood diseases and tumors as well as in the application of radioactive gold Au-198. The requirements for these radioisotopes by our health service are estimated at one fourth to one third of radioiodine requirements.

Radioisotopes are used in diagnostics. A wide range of isotopes is available to diagnose metabolic malfunctions, kidney diseases and heart condition; to detect and locate tumors; as well as for a variety of other tests. The radioisotope unit quantities used in these diagnostic methods are small; but because of the intricate work method only experienced operators may have access to laboratory equipment and instruments. In the future, the importance of artificial radioisotopes will become even greater for modern metabolic, biochemical and physiological medical research, as they will help to discover new physiological interrelationships and thus the causes of many diseases. In this respect Czechoslovakia has made no headway yet, but efforts will be made toward progress.

The primary condition for the development of the medical application of radioisotopes is to set up a basic radioisotope department to work with the research institutes subordinated to the Ministry of Health. The department will develop the necessary basic methods and will train physicians, biochemists, medical physicists and their assistants. The Department will use radioisotopes to diagnose and treat cases which are in the care of and under study by individual research institutes. Because of high cost, it is impossible yet to establish in each institute departments that would handle the intricate work with radioisotopes. Individual institutes can afford setting up only small specialized departments of the first or second category equipped to perform minor activities; departments for more important activities will be an exception. It is therefore necessary to set up a fully equipped central department for isotopes (CIP); it will cooperate with other research institutes; it will be free to choose a methodologic objective of its own. In an effort to train young cadres, we shall establish radioisotopic departments at medical faculty hospitals and eventually at the Kraj

Institutes of National Health as soon as enough trained specialists are available. The network of faculty and Kraj radioisotopic research departments will have the potential of meeting all the urgent requirements of the isotopic project of our health service.

The isotopic medical research program is very ambitious; the basic departments (of CIP and at faculties) will, therefore, pursue several major directions. The most important is the metabolic application of isotopes, whereby isotopes as open agents of radiation are selectively carried to and accumulated in the organism to supply energy to certain tissues or organs. The method of using radioisotopes as closed agents of radiation and the method of teletherapy are being developed by our oncologic departments.

We shall limit our discussion to the departments engaged in the application of radioisotopes as metabolic and as localized agents of radiation. The departments will be divided into clinical, experimental and dosimetric sections.

Clinical Section

The main section is the clinical section, which is responsible for the use of radioisotopes in diagnosis and therapy. Therapy consumes most of the isotopes; and premises must be equipped to assure protection and safety of work with ionizing radiation. Depending on the number of beds and the types of diagnosis it is possible that the amount of radioactivity could exceed 10 curies. This amount is, however, divided into smaller individual doses administered to the patients of the entire section. As a rule radioisotopes are concentrated in certain organs or cavities of the patient's body. Radioactive iodine is concentrated in the thyroid gland, radioactive gold in the pleural or peritoneal cavity, etc. Most isotopes applied metabolically are eliminated in the urine and negligible quantities in the sweat, breath and stool. The section may, therefore, have radioactive centers of varied intensity: the radioactive carriers are the patients; the urine which the patients accumulate in appropriate containers for the purpose of determining the isotope contents in their body; even the linen will be radioactive because of residues of urine and sweat; and so will the objects which the patient touches; there will also be radioactivity due to spray diffusion. Open and closed radiation agents are handled directly each time a dose is administered. The

most virulent carriers of radioactivity are the patients because they move around either actively or passively and physicians as well as nurses come in direct contact with them. Patients contaminate all objects they touch, especially bed linen, dishes and the like. There is always the possibility of a sudden major contamination, e.g., when strongly radioactive urine is accidentally spilled.

The setting therefore requires specific construction work, definite technical and organizational arrangements to safeguard working with radioactive substances. The respective legal provisions have been embodied in the CSN Code No 341730 /Czechoslovak Norms Regulating Work with Radioactive Elements/. The Code reduced to 100 millirems the permissible weekly contamination dose for a worker; the safety requirements have therefore risen considerably. For example, if a tumor or thyroid gland of a patient contains 100 cm of I-131, the intensity of gamma rays, radiating from this source at a distance of one meter, will be 25 millirems per hour; consequently a worker exposed to the rays for over four hours would receive more than his maximum permissible weekly dose of radiation. The section may have at one time several intense sources of radiation; it will, therefore, be necessary to make available to all concerned a map of isodoses showing the area of safe zones and pointing to contaminated zones where access is permissible in most urgent cases only and under the protection of lead aprons or curtains and only for the minimum time required. The curves of isodoses on the map will probably be changing quite often; some contamination sources weaken sooner or later, because the activity of isotopes declines in disintegration curves according to the physical half-life or biological half-life for isotopes that are present in the body; other sources of radiation originate after each new treatment. The variation in the distribution of radioactivity is also due to the movements of patients to the shifting of containers filled with radioactive substances (urine) as well as to the movement of contaminated objects.

It becomes, therefore, imperative to institute a constant dosimetric supervision over the entire section and its employees. Intense radioactive traffic should be confined to precisely determined routes which should not be crossed; they should be entered only with proper precautions. The radioactivity diffused by spraying should be continuously eliminated by an efficient ventilating system; accidental contamination caused by patients should be

constantly watched and promptly removed.

Protection against gamma rays may be sought by keeping distant and behind protective walls or shelters capable of absorbing radiation adequately. The best protection against beta rays is to avoid contamination with and transfer or intake of active agents. The structural design of premises emphasizes protection offered by distance rather than by absorbing walls and ceilings. Suppose in a building several stories high a pipeline carrying off waste matter would suddenly burst between the floors; the active substance could impregnate the lower floors and contaminate precisely the areas that are otherwise perfectly protected by lead. A case such as this could cause the closing of an entire wing for a long time.

The radioactivity of patients in rooms differs according to the dose they received and the time elapsed since the application The initial radioactivity of a patient following the administration of megadoses in the treatment of some cases of thyroid gland cancer reaches several hundred I-131 microcuries. The gamma radiation intensity at one meter distance from the patient may reach up to 100 millirems per hour and increases at close distances even to several rems per hour. The patient's radiation intensity declines rapidly and within about twelve hours drops to one third or to one half of its original volume, because the isotope is rapidly eliminated with the urine. We must take every precaution to avoid contamination while filling urine into the container used for measurement purposes in the ionization room. To make such operations safe they will be performed in a special "hot" room equipped with automatic facilities for the entry and exit of containers filled with radioactive urine. For example, the patient rests on a mobile bed which is directed by remote control to a wall; through it a covered channel conveys the container with his urine to the hot laboratory of the physical section for measurement by remote pipettes while the attending personnel is protected by a shelter. Separate portions of urine are conveyed automatically to the ionization chamber or to some otherlaboratory for the measurement of radioactive intensities. The medical staff observes the patient from a shelter and comes nearer to the patient only if absolutely necessary and only for the shortest possible time while protected by a mobile curtain or some other appropriate object. After most of the radioactive urine is eliminated the patient may be transferred to a room where he remains isolated. His radioactivity stays

concentrated in some part of his body, like in the tumor of his thyroid gland or in the metastasis; the radioactivity gradually declines according to the effective half-life ranging anywhere between 2 to 6 days.

The patient's room remains a dangerous ambient because of his radiation intensity; its value varies according to the actual radioactivity inside the patients. It is, therefore, advisable to separate patients into rooms by groups according to their activity. The highest activity that could remain in a patient ten hours after the application of a "megadose" of I-131 may reach the value of approximately 120 microcurie. The powerful dose is best administered to the patient in the morning to give him the opportunity to be transferred back to his room in the evening; otherwise he would have to pass the night in the radioactive room. The first group of active rooms is therefore reserved for patients having an activity of 20 to 120 microcuries. The gamma radiation intensity at a distance from the patient of one meter ranges from 5 to 30 millirems per hour; it may rise to several rems per hour at a close vicinity to the patient's body. Such rooms are for single beds only and have their own sanitary facilities and bathroom (shower); they are furnished very simply for easy cleaning and decontamination. The patient's highly radioactive urine is collected and kept isolated either in a dark place or in the wall with the automatic conveyor channel. These rooms are suitable for the administration of doses up to 100 microcuries conveyed directly to the patient's bed. The same method is used to carry food and other supplies to the patient; the contact between hospital staff and patient will thus be limited to activities that cannot be carried out by remote control (care for the patient, etc.); but even in this respect work will be eased without curtailing the care for the patient; e.g., the position and the slant of the bed will be automatically controlled.

The second group will be constituted of rooms for medium radiation intensity ranging from 1 to 20 microcuries. The gamma radiation at a distance from the patient of one meter is between 0.25 and 5 millirems per hour; at a close vicinity to certain parts of the patient's body the intensity may rise to one rem per hour. The rooms will have two beds furnished with the necessary sanitary facilities and shower. Adequate measures will be used to protect the staff from the radiation effect of radioactive urine.

The third group of rooms will be reserved for radio-

activities ranging between 0.1 to 1 microcurie; the I-131 radiation intensity at a distance of one meter does not exceed 0.25 millirems per hour; only in the vicinity of some patients may the intensity in a certain place of their body reach 100 millirems per hour. The radioactivity of the urine portions collected in containers does not register more than 0.5 microcuries; no special safety precautions are therefore necessary. The rooms will have several beds and will be furnished with their own sanitary facilities. The fourth and last group of patients are those whose total radioactivity does not exceed 100 microcuries (patients exposed to isotopes for diagnostical purposes). This group may be accomodated in common rooms together with other nonactive patients; they are released into home care as soon as their activity drops below 20 microcuries.

The most favorable approach to an economical arrangement of rooms is the system of transferring patients to rooms according to the degrees of their radioactivity. For example, after the administration of a megadose in the morning the patient is transferred in the evening to a room with a single bed set up for radioactivity ranging from 20 to 120 microcuries. These rooms are occuped also by patients immediately after they receive a dose of 20 to 120 microcuries. When the patients' radioactivity drops below 20 microcuries they are transferred to rooms equipped for activities ranging from 1 to 20 mircrocuries; these rooms are occuped also by patients immediately after they receive a dose within that category. Patients are kept there until their activity drops to one microcurie; they are then transferred to common low-activity rooms where microcuries range between 20 and 1; the common rooms are also occupied by patients with higher diagnostic doses received for scintigraphic examination, etc. The length of the patient's stay in the respective category depends on the effective half-life of the administered dose. Once the patient's activity drops below 20 microcuries he is either released or transferred to a common nonactive room. Depending on the type of treatment given we may choose other classification criteria and reduce or increase the number of different radioactive categories. By using this sliding method, we may keep the map of radioactivity within certain limits for the entire section and utilize all facilities efficiently since the premises are built and equipped for specific radioactivity levels. The transfer of patients, even if they are immobilized, can be effected with utmost care and safety, e.g., in an appropriate isolated conveyor that can carry the entire bed safely, etc. The layout of

doors and connecting sections must therefore be well planned. For I-131 treatment we use, according to the sliding room classification method, 4 percent of beds for activities exceeding 20 microcuries; 12 percent of beds for 1 to 20 microcurie activities; 38 percent of beds for activities ranging from 100 microcuries to 1 cm; and 46 percent of beds for activities below 100 microcuries or for nonactive cases. The last group of beds pertains to the category of departments engaged in work with lowest radioactivity; it does not require all the sanitary protection decreed by the CSN Code for categories working with higher activities. Part of the first category's bed fund may be used in other departments or institutions, which closely coöperate with the isotope bed department. Consequently, the socalled hot beds, located in the area divided by sanitary anterooms into sections for patients and hospital staff respectively, will be distributed as follows: 7 percent in single-bed specially equipped rooms for high activities (from 20 to 120 microcuries); 21 percent in rooms with two beds for activities ranging between 1 and 20 microcuries; and 72 percent in rooms with several beds and activities to 1 microcurie. For the treatment with other types of isotopes and for other research objectives the time and percentage relations will vary somewhat.

The sliding room classification system requires a construction design whereby the most active section of the department is isolated and projects into one direction.

The structure will have a minimum of background area in all connecting corridors, in service and inspection rooms and wherever there is no direct contact with radioactivity; the reason is that exposure should not be allowed to bear on the permitted weekly average dose of 100 millirems. We have set this safety limit so that the surrounding area does not share in these 100 millirems with more than 10 percent during a 36 hour working schedule; we also are aware of the fact that such a dose may be acquired by a hospital worker within minutes in some emergency cases through direct exposure; it will therefore be necessary to keep the radiation intensity in said areas down to 280 microroentgens. This is about twenty times the average intensity to which the rest of the population is exposed. It is therefore recommended to arrange isolated rooms with highly active beds on one side of the corridor only. The other side of the corridor should have windows leading into the open. The opposite wing of the building will house rooms with the lowest radioactivity, laboratories,

measurement rooms, for low activities, inspection rooms, kitchen and sanitary rooms. In front of these premises will be the nonactive area with rooms for employees (the CSN code prohibits eating and smoking of employees in the working area), administration and consulting offices. This part of the building should be connected with nonactive beds or beds registering activities up to 100 microcuries and to the ambulatory section which works only with lower activities.

There is always the possibility that a patient in the active bed section suddenly dies shortly after having received the highest doses. The entire corpse becomes a source of radiation with its intensity declining according to the disintegration curve of the administered isotope. The direct handling of the corpse exposes workers to a high degree of radiation. We therefore connect the isolation room with a remote control device to convey the bed with the corpse to the autopsy room's cool dark compartment; it will rest there until its radioactivity drops, as a result of the natural isotope disintegration, to a degree permitting safe handling.

The situation changes in case of a patient's death occurring several days after the administration of radioiodine; the isotope is concentrated in the single affected organ or in the solitary metastasis of the tumor. The procedure will be a fast removal of the critical organ from the corpse; the corpse's activity then drops to a minimum and there is no further danger of exposure. The removed organ is placed into a tinted vessel filled with a fixing agent for further processing, e.g., for histoautoradiography. The procedure will be carried out with all necessary precaution against exposure in an appropriate room connected with the room occupied by the bed. Autopsy of radioactive corpses requires extraordinary technical and organizational measures to protect against gamma radiation and beta ray contamination, but should permit freedom of movement to the physician performing the autopsy. We have not yet solved the problem of the right protective measures to be applied in these cases; in the meantime, we shall therefore perform the autopsy only after the corpse's radioactivity has vanished.

Another major problem is that of performing surgery on radioactive patients. This problem may be divided into three categories: 1) emergency interventions made necessary after the administration of isotopes, e.g., acute

tracheotomy; 2) interventions made necessary for reasons other than the administration of isotopes; 3) surgical administration of isotopes and complex radiosurgical treatment.

Most operations of the first category may be carried out directly with the patient in his bed or in the surgical room of the surgical section of the isotope department. The method may also be used in emergency cases not related to the isotope administration. The surgical room should be designed for a broader purpose and serve for s geries of gynecological, urological and optical nature. The broader scope will benefit the third surgical category (surgical isotope administration in the form of open or closed radiation agents and radiosurgical methods of treatment). These methods were introduced several years ago and have been successful in the treatment of some advanced tumors. We refer here to surgery of malignant tumors following a pre-surgical administration of isotopes. Very demanding facilities protecting against gamma rays are required for certain localized surgical operations and for radiosurgical interventions; we stress the importance of isolation and protection from radiation emanating from the surgery table and while leaving enough freedom of movement to the surgeon and his staff. The sickbed department will have spaces for the deposit of radioactive material and linen which must not leave the department as long as it remains contaminated. A small laundry room connected with the radioactive waste will be adequate for rapid decontamination. If the laundry method proves inadequate, we shall put the linen in storage rooms for the disintegration of short half-life isotopes: other linen will be disposed of altogether as radioactive waste if contaminated with isotopes of long lasting half-lives.

The low radioactivity section of the isotopic department is connected with the ambulatory room and with diagnostic installations which operate with low doses of isotope. Rooms used for the measurement of low activity will be arranged to protect sensitive instruments from possible intense radiation in the room; e.g., close-by X-ray instruments would cause interference. Some measurements will have to be made inside the radioactive area but not before the sensitivity of instruments is reduced. Some instruments may be carried to the sickbed, others (the scintiscanner and the profile gammagraph) require separate rooms. The active inside area will be equipped with auxiliary laboratories for X-ray diagnosis and hemotology,

in the latter case the doses ranging between LD_0 and LD_{50} may provoke changes of the blood pattern calling for an immediate transfusion or other methods to protect blood creation.

Experimental Department

The tasks of the experimental department are closely related to the tasks of the clinical department, but the nature of the experimental radioisotope work is somewhat different. The dosage has a range of 10^{-3} curies and is consequently three times lower than the dosage administered by therapy.

On the other hand the range of radioisotopes is much wider; whereas the clinical department uses radioisotopes with a short-term half-life, the physiological and biochemical work is done with many long-lasting radiation agents, such as C-14 and Sr-90. The lower dosage, to be sure, reduces the risk of external exposure, but the method of applying and processing the material increases the possibility of infecting the organism with open radiation agents. Strict sanitary measures are therefore enforced in laboratories and particulary in work with animals. The radioactive zoo, the physical and biochemical laboratories shall be equipped with a perfect ventilation system and most work with open radiation agents shall be done in digesters or gloved boxes. All work will be subject to a constant contamination control of all surfaces, work areas, containers, tools, hands and clothing. The control and the dosimetric supervision are the responsibility of the physical section of the radioisotopic department which is provided with all the needed technical and personnel facilities.

The physical section of the radioisotopic department is responsible for:

1) Coordination of radioisotope planning in the entire department;
2) Ordering radioisotope shipments and the storage of supplies;
3) Distribution of radioisotopes to sections concerned;
4) Dosimetry of radioisotopes for all sections;
5) Development and standardization of dosimetric methods;
6) Dosimetric calibrating service for all sections;
7) Physical consulting service for all sections;
8) Solution of the department's own research problems;

9) Dosimetric health and physical control service;
10) Supervision and responsibility for the observance of laws.

On the fulfillment of these duties rests the entire operation of the radioisotopic department. To carry out its duties the physical section will have adequate room, personnel and facilities at its disposal; from a legal standpoint it will enjoy a fully autonomous position.

Adequately equipped sections of the department are a prime necessity, but strict compliance with the operational code remains the basic principle for safe operation. The code must be prepared in every detail and specifically for each department; consideration will be given to local conditions of the department concerned provided they conform strictly with the CSN code now in effect.

Summary

The authors discuss the principles of work with radioisotopes in the health services from the aspect of protection from ionizing radiation of the workers involved. From the same aspect, the problem of the equipment of these departments is discussed in detail and the problems of the working regimen at the clinical and experimental departments are dealth with.

JPRS: 5863
CSO: 4323-N/b

Czechoslovakia

PROJECT FOR RADIOISOTOPE LABORATORIES AT THE MEDICAL FACULTY IN HRADEC KRALOVE

/The following is a translation of an article entitled "Projekce radioizotopovych laboratori pro lekarskou fakultu v Hradci Kralove" by O. Steinbach published in Ceskoslovenske Zdravotnictvi, Vol VIII, No. 2-3, Prague, 1960, pages 131-138./

The development of nuclear power for peaceful uses in Czechoslovakia has become of major importance. We have started operating our own atomic reactor that releases a considerable volume of radioactive material, which until recently had to be imported from abroad. We have now the foundations on which to expand our radioactive substances for use in our industry, agriculture, health services and research work.

The Government Decree of 25 July 1957 states in Article 1 that "research is to assure a broad utilization of radioisotopes by science, technique and medicine". Thus was created the basis for an unprecedented rise in the use of radioactive materials by all categories of science; the incentive was stimulated for projects and construction of centers engaged in work with radioisotopes.

Among the projects figure the Experimental Radioisotopic (RAI) Laboratories in Hradec Kralove.

The project will become an asset to our national economy provided we make its operation safe and avoid any danger to the health of workers.

The project, prepared in 1958, was based on domestic and foreign experience. It was preceded by a scientific visit to the USSR, in the course of which many problems relative to the intricate operation of RAI laboratories were cleared up in cooperation with our Ministry of Health, the Moscow Project and the Moscow Health Project.

* * *

The laboratory will concentrate its work on biological and biochemical problems arising from the application of radioisotopes. Radioisotopes will be used as indicators of chemical processes and will help in following physiological processes; they will also serve as sources of ionized radiation for biophysical purposes.

Operations will be classified accordingly into several categories and will be performed in the following centers:

Biochemical laboratories
Analytical laboratories
Microbiological laboratories
Dosimetric laboratories

For biological and physiological research, we plan to set up a zoo, surgery and autopsy rooms equipped with all necessary facilities. The nature of the center dedicated to research does not put any limitation as to the radioisotopes to be used. However, the actual application of radioisotopes will given an approximate idea as to the range of common radioisotopes.

Table of Planned Radioisotopes

Beta Radiator	Beta-Gamma Radiator	Gamma Radiator
C -- 14	Ka -- 24	Mn -- 54
P -- 32	K -- 42	
S -- 35	Fe -- 59	
Ca - 45	Co -- 60	
Sr - 98		
J - 131		

Energy Levels of Gamma Radiation

Eg =	0.722	MeV
	0.637	MeV
	0.364	MeV
	0.284	MeV
	0.162	MeV
	0.080	MeV

Amount = 0.27 mg equal to Ra per microcurie
the constant total dose of gamma radiation
2.30 rems per hour half-life = 8.14 days

Maximum Volume of Radioactivity of Individual Radioisotopes

groups X maximum volume 50 microcuries (Na-24, Ka-42)
groups Y maximum volume 5 microcuries (C-14, P-32, S-35, Mn-54, Fe-59, Sr-98, and J-131)
groups Z maximum volume 0.5 microcuries (ca-45)

Current operations in all laboratories will be limited to the range comprised in the second category, in accordance with the provisions of CSN Code No. 341730 (Czechoslovak Norms Regulating Work with Radioactive Elements).

In exceptional cases and for a limited time only operations will comprise a volume of radioactivity larger than the volume authorized by the Code for the second category. We shall also contemplate using radioisotopes other than those mentioned above. In order to safeguard the radioactivity reduction potential of the walls we have established specific limits for the volume of radioactivity that may be placed against the wall in any given room; this will keep down and within limits the volume of gamma radiation penetrating into the neighboring room.

Helpful Data for the Solution of Technical Problems

1) The total radioactive volume in the future laboratories shall not exceed 1,000 microcuries per annum.
We estimate that one quarter (200 microcuries per annum) of this volume will be radioactive slops; the daily volume of radioactive liquid waste will consequently be below one microcurie.

2) Volume and type of waste:
Liquid waste: organic (urine, blood) -- 200 liters per day
anorganic (waste water from laboratories and washrooms) -- 1,000 liters per day
Solid waste: organic (stool, dead animals, half-life) -- 100 days
anorganic (cotton, paper, glass) -- 1 cubic meter in 10 days

3) Radioactive intensity of liquid waste: up to 10 microcuries per 1,000 liters:
Radioactive intensity of solid waste:
organic: 1 microcurie per kilogram

anorganic: 0.1 microcurie per kilogram

4) Duration of waste storage:
liquid for one week - half-life of 100 days
solid anorganic - 1 to 2 months
solid organic - dead animals will be removed weekly to concrete pits outside the hospital area.

5) Number of animals for experimentation: monthly volume of animals is estimated at:
10 dogs
40 rabbits
50 guinea pigs
100 rats
400 mice
For permanent stabling we estimate that the following equipment will be needed:
100 metabolic glass cages
20 large metabolic cages

6) Number of laboratory workers:
15 men
15 women
All will be engaged in hot operations.
Nature of work:
receiving isotopes, transferring isotopes to individual departments, distributing isotopes, preparing solutions, applying isotopes, receiving biological material, measuring radioactivity, cleaning and decontaminating containers and aids, chemical analysis and synthesis, marking biological material, chemical processing of tissue samples, mineralization, disposing of liquid and solid waste.

The RAI laboratory project in Hradec Kralove was conceived on the basis of the following three major principles of N. B. Garden:

a) Work involving radioactive radiation must be performed with a minimum danger for employee and surroundings;
b) Work must offer accurate and safe results;
c) Work must be economically feasible which is the result of the two preceding premises.

The plan, based on the above principles, places the pavilion accordingly at the end of the hospital zone in an isolated location at a distance of over 100 meters from all other clinical premises and in the direction of trade

winds. The pavilion was designed as a one story five aisle structure with a cupola over the center aisle for better lighting.

The pavilion is divided according to radioactivity into three zones:

white zone where contamination is practically nonexistent; pink zone which is exposed to contamination; red zone where the nature of work must lead to contamination.

All three zones (white, pink and red) of the pavilion are divided in a longitudinal direction according to sanitary requirements into two sectors:

laboratory and research sector, where no animals are used;

sector for work with animals.

The division according to the level of radioactivity has a sequence pattern, whereby the animal zone with the highest radioactivity is followed by the laboratory for blood testing and isotope storage; then radioactivity drops further in the laboratory for the synthesis of substances and the processing of biological material; finally the lowest activity is in the organic laboratory.

The declining gradient of radioactivity applies to the second (pink) zone with the following sequence pattern: animal stable, autopsy room, surgery hall and contaminated washroom.

The end of the pink zone houses a clean washroom, darkroom with autoradiography and dosimetry; they all may be entered from the white zone only.

The white zone takes care of the zoo requirements: storing and preparing fodder, receiving animal consignments and readying animals for experimentation. The zone has a workshop for fine mechanics, accessible from the corridor but not linked with the animal section. The following additional facilities are recommended for the white zone: nonactive laboratories, weighing room, library and reading room, study hall for physicians, offices, wardrobe and recreation room for personnel.

The main laboratory entrances are located in accordance with the above mentioned layout for the respective zones.

Personnel

Personnel enters through the main gate into the white zone furnished with separate wardrobes for men and women. Employees are required to check with the office prior to entering the pink or red zone. The office, equipped with a control board, is linked by telecommunication with all laboratories and auxiliary services.

The control board is equipped with the following devices:

1) Electric control of the main building entrance; this prevents any unauthorized access to the white section.
2) Electric locks controlling the connection between the white and red zones. The lock to the red zone is not released until the zone has been first made ready for operation by a thorough ventilation lasting 15 minutes.
3) Signaling devices relating to the proper functioning and any trouble of the ventilating system.
4) Radioactivity in laboratories is automatically relayed and any excess of the prescribed maximum radiation intensity level is immediately reported.
5) The radioactivity of waste water is signaled before and after the diluting process. All precautionary and safety measures are taken in advance in case of an accident.
6) Three public telephone lines and 25 internal exchanges connect all rooms. The white zone has a regular press-button telephone system; the pink and red zones use a foot pedal to operate the telphone that is built into the wall and protected by plastic insulation. The animal zone has a tentative two-way telephone communication linking the laboratory with the animal food supply room and, at the same time, with the control board.
7) The control board has two magnetophones recording any message from the pink and red zones. A device for written recording is being tested.
8) The control of incoming and outgoing messages permits receiving reports and issuing orders at the same time through all 25 exchanges.
9) The electric time of the control board is communicated to all laboratories.

Employees enter the zones through a sanitary anteroom where they change into work clothes for hot operations (marked red); they are handed a film dosimeter and a twin ionizing gamma ray recording box. They don galoshes before entering the red corridor leading to their respective

laboratories. When leaving the pink or red zone, they remove their protective clothing (marked red) and place it in a locker. If their clothing or shoes are contaminated, they deposit them in a special container for laundering in the decontamination room to reduce activity to the permissible degree.

Employees use a shower and a drying room; on the door of the red wardrobe opening into the shower and the shower in the anteroom have automatic gauges controlling radioactive contamination.

Animals

Animals for experimentation are consigned to the receiving room and stabled in the reserve zoo of the white zone. From there they are transferred into metabolic cages through receiving windows (mice, guinea-pigs, rabbits) or through parapet doors underneath the windows (dogs, apes). Large animals (dogs, apes, rabbits) will in the future be housed in airconditioned metabolic cages furnished with disinfecting shower. The cages are built to permit separation of urine from feces for examination and gauging purposes.

The large animal zoo has two corridors, one for laboratory personnel and the other for feeding personnel; the latter connects with the decontamination room.

Dead animals are disposed of as solid waste. Part of the dead animals will be left under appropriate refrigeration for several days until they loose their radiation; another part will be kept in special containers or concrete vessels.

Fodder

Animal fodder is shipped to an appropriate storage through the entrance located near the animal receiving post. From there it is brought to the kitchen located in the center of the zoo.

Prepared fodder is passed through windows to the red zone and is carried to the zoo. The rest of the fodder is disposed of as solid waste.

Unused Laboratory Glass and Aids

They are carried to the red zone through a window in

the non-contaminated washroom. The non-contaminated washroom is used mostly in connection with operations in the white zone.

Used Glass

Used glass, concentrated in the washroom for radioactive glass, is immersed into a caustic solution (acid or lye) for not more than eight hours. It is then rinsed with water and placed into a closed glasswasher for warm water rinsing. The glass is thereupon gauged for radioactivity. If radioactivity does not exceed the permissible limit, the glass is immersed into sulphuric chrome acid, rinsed, dried in mobile electric dryers and carried directly back to the respective laboratory groups.

Liquid Radioactive Waste

The structure of the building determines the division of the sewer system into three categories:

a) surface conduits channeling rain, roof and surface waters from firm areas and communications;
b) conduit for the removal of nonactive slops into septic tanks; the conduit is connected with surface water sewers;
c) active slops, gauged to one microcurie volume per day but not contaminated with solid matter, are carried by a separate conduit to the diluting station.

Radioactive solutions known to have low radioactivity may be poured into laboratory wastes. Highly radioactive liquid waste (residues of certain solutions for injections) are neutralized, evaporated and the residues are held as solid waste.

The sewers for active slops, as part of the water, steam and heating pipeline system, are conveniently accessible for inspection and for parts replacement.

The pipeline for the collection of slops ends in a distributor cistern in which the slops are diluted.

The distributor cistern has locks controlling the discharge of slops into diluting tanks. The degree of radioactivity determines the volume of water to be supplied to the tank through a pipe that makes the water circulate. The diluting tanks may be operated alternately and may be also shut off for cleaning. The system of two diluting

tanks offers the possibility of adding neutralizers and coagulants. Once the dilution reaches the degree prescribed by the CSN Code No. 341730, the diluted slops are discharged to another tank where a pump and its floater regulate their drainage into the sewer.

In case the diluting tank is damaged, the tank with the pump steps in to continue the dilution by water supplied to it in the same manner as the diluting tank; in this case the action of the floater is turned off while the dilution process is going on.

Over a certain period of time radioactive sediments will accumulate at the bottom and on the walls of tanks. They will be removed and discharged into the tank that has the pump; from there the radioactive mud is sucked off by a specially built unit and disposed of as any other solid waste.

The full capacity operation of the ventilating system requires the supply of 100,000 liters of water, which is a volume adequate to operate the diluting process.

Samples of water are taken from the tanks with probes that come with a closing head.

The diluting system is built underground and has a waterproof insulation to prevent any water from escaping into the open.

An auxiliary well-water pump with a capacity of 16 liters per second is installed in addition to the submersible pumps.

Radioisotopes

Radioisotopes are conveyed by a small electrical overhead track to the storage room, where they are deposited in an underground automatic two-tier safe, divided into compartments storing quantities corresponding to two curies. Radioisotopes may also be stored in six auxiliary cylindrical containers. In addition to that a maximum of 1,000 microcuries may be stored in a 40 x 40 x 36 centimeter safe.

Radioisotopes are divided into doses and carried in shipping containers to the respective laboratories or passed through the storage room window directly to the

chemical laboratory. Each laboratory has its own midget storage space built into the wall.

Solid Radioactive Waste

It will be classified according to the degree of contamination. Ordinary radioactive waste, solid dry noncorrosive and nondecaying residues are placed into plastic bags; most of the waste are paper napkins, clogged cotton, rejects of glass containers and instruments. The bags will be deposited in garbage drums which are hermetically closed by a high frequency device prior to being carried away.

Part of the solid waste will lose its radioactivity after several days (some dead animals left in refrigerators; part of the zoo's residues and of the laboratory's waste left in the cellar).

The rest of organic waste matter requires special handling and will be deposited in soldered cans of varied sizes or will be cemented into prefabricated pits (various organic waste matter contaminated with gamma-beta rays with long disintegration half-lives originating in the microbiological and biochemical laboratory; dead animals, litter with food residues; semisolid filth of washrooms).

The cans will be sterilized to prevent any occurrence of gases in unfilled spaces.

The neutralization of solid waste will be done in the building's decontamination room connected with the zoo's corridor. The decontamination room is planned to have facilities for the decontamination of laundry, precious glass and instruments, to rid them of solid radiation agents with long half-lives.

The wall between the red corridor and the decontamination room will have a built in matrix in which ambulant gloved boxes will be installed; this arrangement will permit the removal and simultaneous decontamination of contaminated material, without exposing the laboratories themselves to contamination and without the box entering the decontamination room.

The entrance to the decontamination room leads through another sanitary anteroom (second in sequence); it will be furnished with a wardrobe for special protective

clothing and a shower for the superficial cleaning of the clothing; furthermore, it will have a gauge to measure radioactivity.

The decontamination room leads through to a subterranean gangway to the station for diluting radioactive waste waters. Solid waste matter is carried through a special exit directly to a shed, rinsed and removed for storage to an appropriate place assigned for that purpose by the health officer of the Kraj.

Protection of the Laboratory Atmosphere

The plan for the health protection equipment was designed to suit five sections according to the nature of their operations: laboratory, radioactive zoo, surgery rooms, uncontaminated zoo, decontamination.

There will be special airconditioning equipment available for: digester, dustproof boxes, body dryer, dark room.

Most of the airconditioning control system is located in the main machine room of the administrative section. The machine room is divided into groups for filtering, mixture and fan chambers; it also has a rotating electric air-pump, a vapor divider and an electricity distributor. Outside air will be drawn through a joint raintight grating set in the window on the northern side of the building into the walled up bottom pressure chamber; from there the air is distributed into the respective units. The exhaust of stale air from the suction fans in the main machine room, is effected by a joint brick chimney passing through and on top of the roof of the building.

One section of the ducts is made of galvanized steel conduit and the other of brick ducts. The airconditioning equipment is obtained from current production. One component that must be made to order is the paper filter used to clean radioactive air in the digesters, dustproof boxes and metabolic cages for large animals; the filters must be secured by the user himself.

The airconditioning system in laboratories will produce a bottom pressure graduated according to the laboratory's radioactivity; it will control the flow of air to prevent the current from flowing from places with higher radioactivity to places with lower radioactivity.

The airconditioning system is instrumental for a flawless progress of laboratory work. Should there be a breakdown of any part of the equipment, we have thought of installing a set of electric twin fans with automatic switches and signaling devices connected with the control board.

A special device will be installed to control moisture and cooling and to perform the second filtration of the air intake.

Each digester and dustproof box is connected with a separate suction equipment consisting of a roof suction unit, of a special box filter located above the digester or above the dustproof box in the room, and of a connecting duct. The output of the suction unit for the digester is gauged to the prescribed intake velocity of 0.5 m per second; its operative opening has a dimension of 0.35 m^2 which includes the tolerance for any opening in an incompletely tightened shield; the volume of air required per hour will be 630 m^3.

The building's airconditioning system will have an automatic electric pressure control with a pilot circuit switch for winter and summer operation.

The atmospheric control in the RAI laboratories will be tested on a model standing 150 cm above the floor, connected with the suction equipment of the laboratory and with the vacuum ducts.

System of Operation in RAI Laboratories

It is the 3D method (Dilute, Disperse, Decontaminate). All operation will be performed in contaminated laboratories controlled precisely as the words indicate: by dilution, dispersion and decontamination.

Each laboratory has its own preparatory room, classified into specific categories according to the type and volume of radioactive matter which is being processed there. The preparatory room leads to one or two laboratories, always separated from the other by a protective concrete wall and by a door panel.

If any different technology of operation is required the panels are readily removed to make a larger room.

Construction Design

The RAI laboratories are designed as a brick shell building with the interior masonry either in brick or concrete according to specifications.

The reduction of radiation intensity for the different masonry types followed the method of N.V. Gusev[1]. Among the planned gamma radiation media, the NA-24 agent has the highest constant ionization dose of Iq = 19.06 per hour. It will therefore be necessary to watch carefully the applicat on of this agent and to make advance computation for all around protection.

The plan for concrete masonry contemplates the use of ordinary concrete with the specific weight of 2.3 kgm per cm^3; the brick masonry will have a specific weight of 1.45 kgm per cm^3. Windows can be opened for natural ventilation; they will be kept closed during operations so as not to interfere with the airconditioning system. The pink and red sections will have concrete floors with an even surface covered by a mat topped by linoleum that will fit without leaving any crevices. Walls and ceilings will have a smooth surface that will be coated with a spray.

Floor and walls will be connected with a rubber ledge, which will have a five centimeter deep bottom groove to make the floor and wall work an even unit.

All laboratories will be illuminated by dustproof lighting fixtures; their surfaces will be dusted in regular intervals. The water, gas, garbage, electrical and communication systems will be installed in the ceiling and floor to comply with the principle of keeping the room surface completely even.

The project contemplates the installation of a complete modern interior equipment for automatic underground dish-shaped safe, jet action glasswasher, stand for small metabolic cages, a large metabolic cage and a body dryer.

The radiation will be powered by an independent small unit, which was selected for reasons of economy; it will operate cobalt radiation of250-500 Curies Co 60.

---

1) N.V. Gusev: Spravochnik po radioactivnim izluchenim i zashtite, published in Moscow in 1957.

The project was prepared in accordance with CSN Code No 341730 of June 1956. Experience and improvements made since then with this and other projects were incorporated into the 1 July 1959 amended version of the Code.

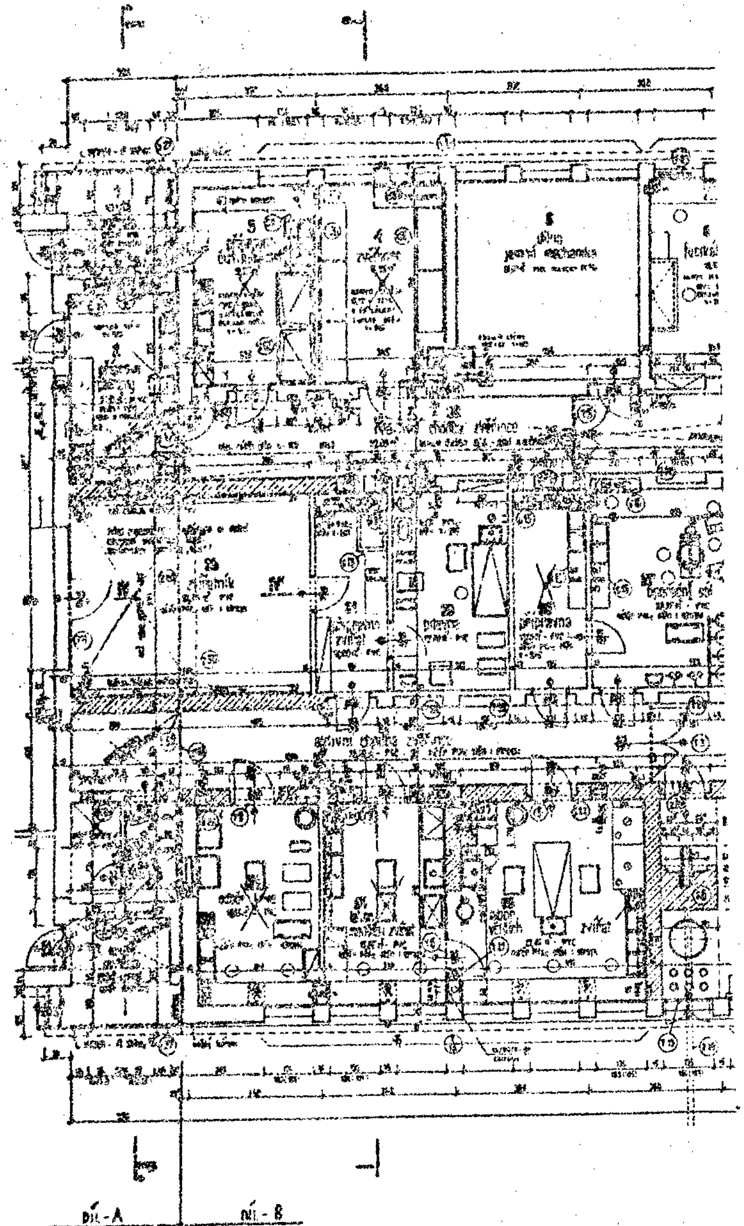
Summary

This is a brief outline of the project for radioisotope laboratories (RAI). One part of the blueprints is published in the annex to this article. The discussion concerns important problems related to the operation in the RAI laboratories, which ultimately determine the project's architectural design. The article elaborates on the work plan for laboratories and the specialization of their working procedures; on the radioisotopes to be used; the classification into categories according to the CSN Code No 341730; the basic technical data necessary to run the project; the principles on which the project is founded; the zoning according to degrees of radiation (white, pink and red zones); the division into sections for animals and for laboratories. Emphasis is placed on the proper policy to govern the start of operations; on the central control of the entire laboratory complex; on the supervision of every movement of personnel, animals, food, glass and aids, radioisotopes, liquid and solid waste; on the protection of the air in laboratories.

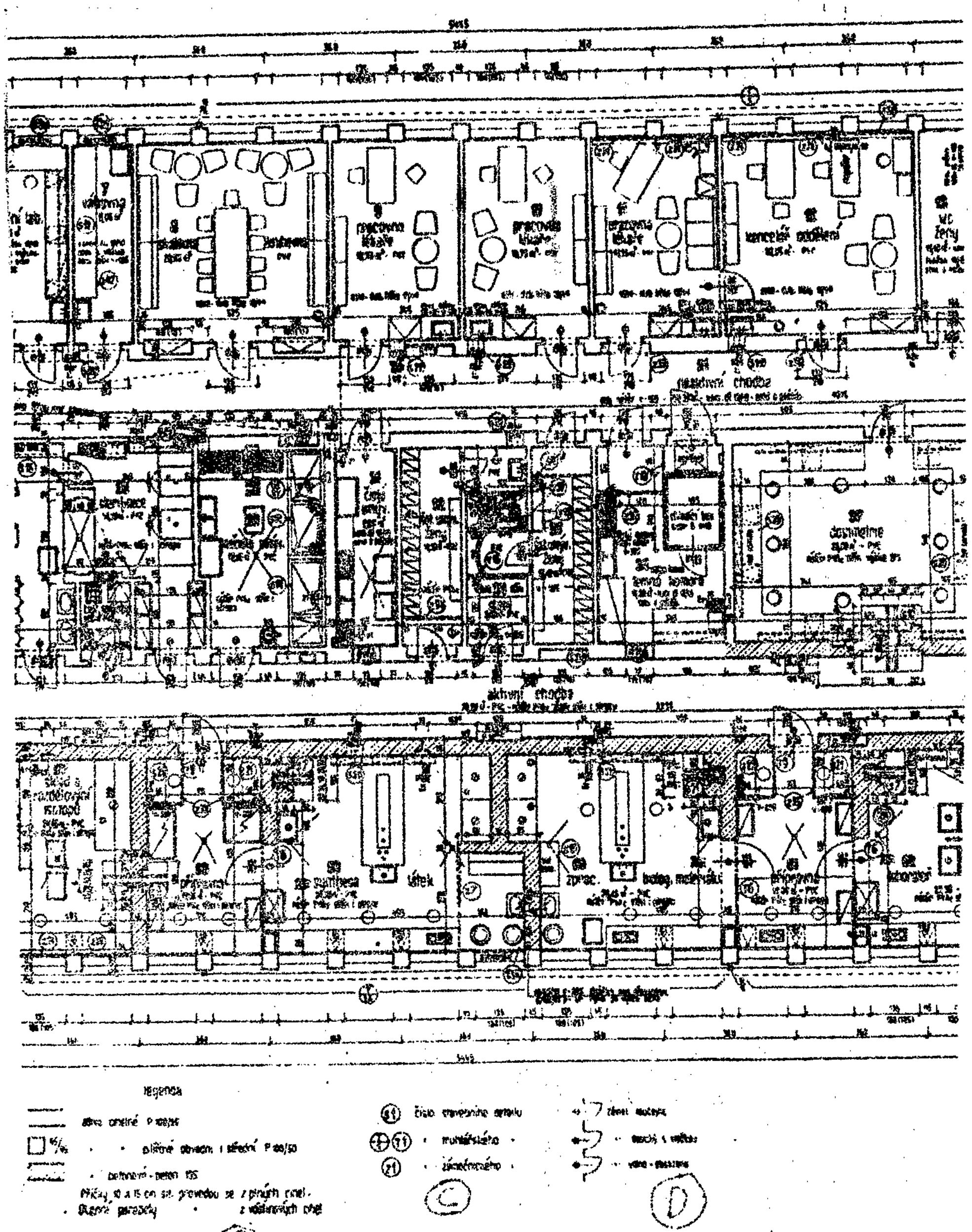
S U P P L E M E N T

Radioisotopic Laboratories for the Faculty of Medicine at Hradec Kralove

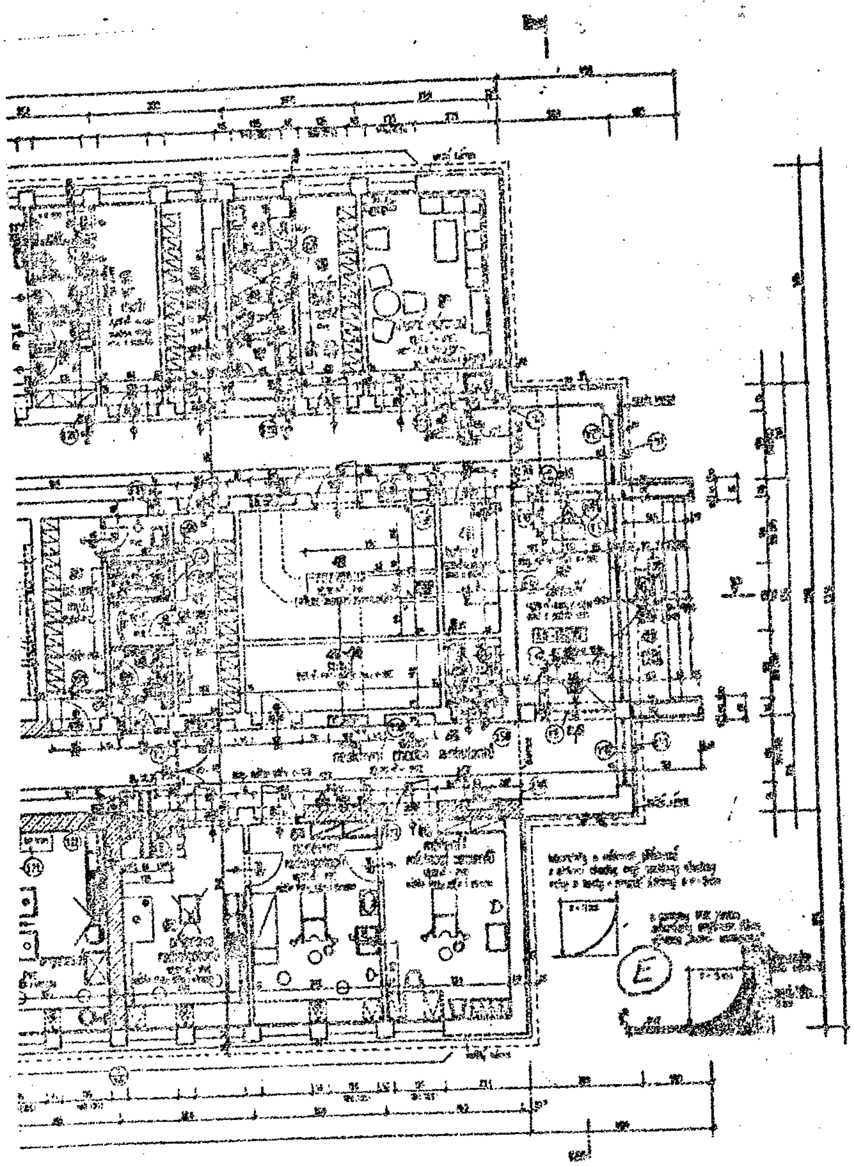
Main Floor of the Experimental Section of RAI Laboratories



/Continued on next page/



/Continued on next page/



[Continued on next page]

1, 53 - covered landing on top of stairs
2 - food preparation
3 - cleaning room
4 - zoo
5 - precision instrument shop
6 - physical laboratories
7 - weighing room
8 - study and library
9, 10, 11 - physician's studio
12 - offices
13 - ladies' room
15 - men's room
16 - men's bathroom
19 - ladies' bathroom
20 - recreation room
21 - non-active corridor
22 - non-active zoo corridor
23 - zoo
24 - animal preparation room
25 - anatomy
26 - preparation room
27 - surgery
28 - sterilization
30 - contaminated bathrooms
31 - clean bathroom
32, 35 - ladies' wardrobe and bathroom
34 - storage
36 - dark room
37 - dosimetry
38, 41 - men's wardrobe and bathroom
42 - distribution
43, 44 - storage
45 - battery
47 - hall
48 - synthetic stone
49 - non-active ambulatory corridor
50 - active ambulatory corridor
51 - active animal corridor
54 - blood test
55 - small animal laboratory
56 - large animal laboratory
57 - storage and distribution of isotopes
58 - preparation
59 - synthesis of substances
60 - processing of biological materials
61 - preparation
62 - organic laboratory
63 - preparation of radioisotopes
64 - radioisotope supply room
65 - measurement, patients' room

A-(Dil A) Part A

B - Brick Walls P 100/25
Outer and center brick wall columns
Concrete walls - concrete 135
10 and 15 centimeter wide crossbars made of full bricks
Window parapets made of honeycomb bricks

C Number of the construction detail
Number of the cabinet detail
Number of the locksmith detail

/Continued on next page/

D - Regular lock
Lock with insert
Free - Occupied

E - Laboratories and rooms, accessible from the active corridors, have all their corners and nooks round-shaped - ceilings and floors have rubber lath connecting ends.

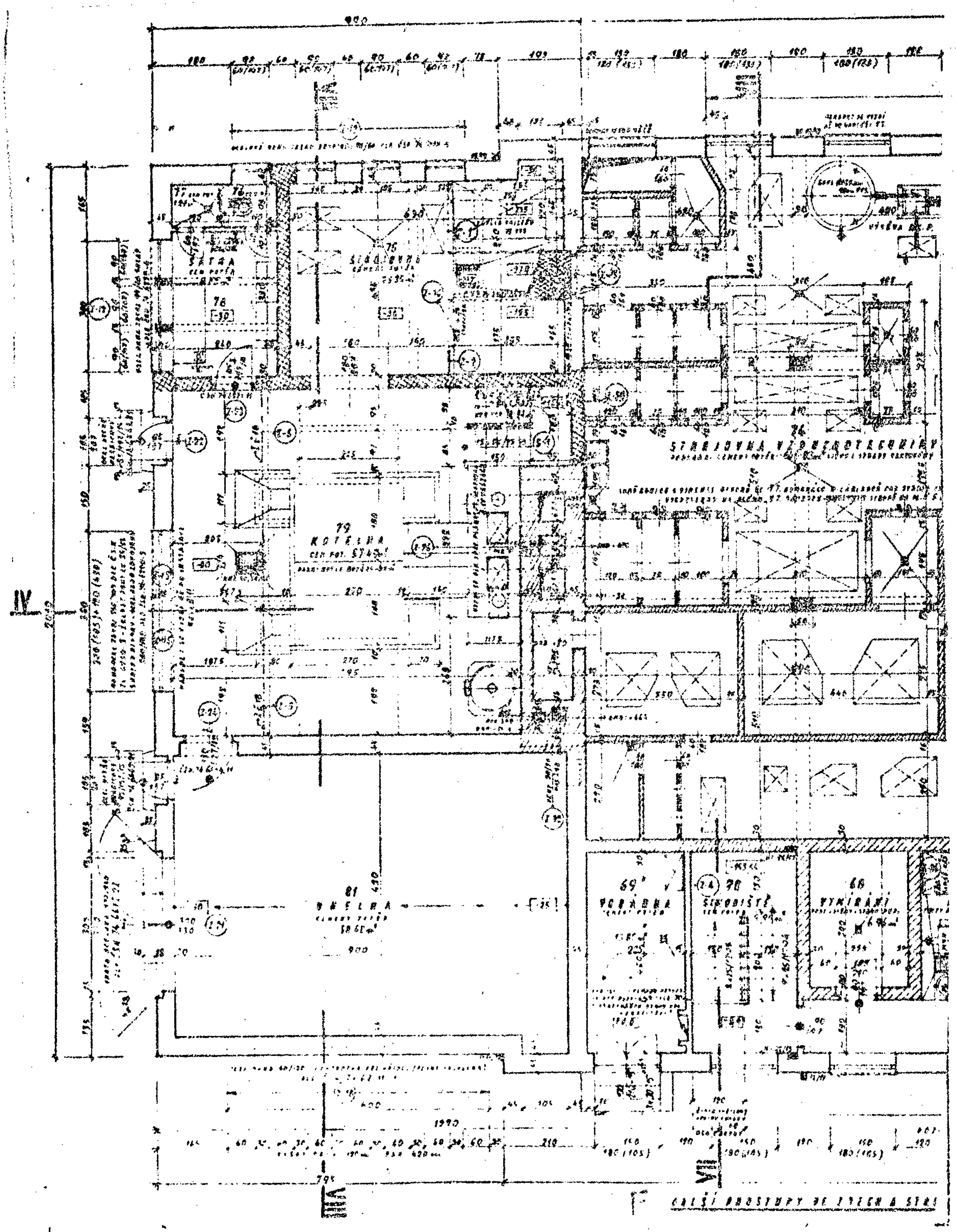
Main Floor of the Administration Section and Zoo in the RAI Laboratories

[The diagram is on the following two pages.]

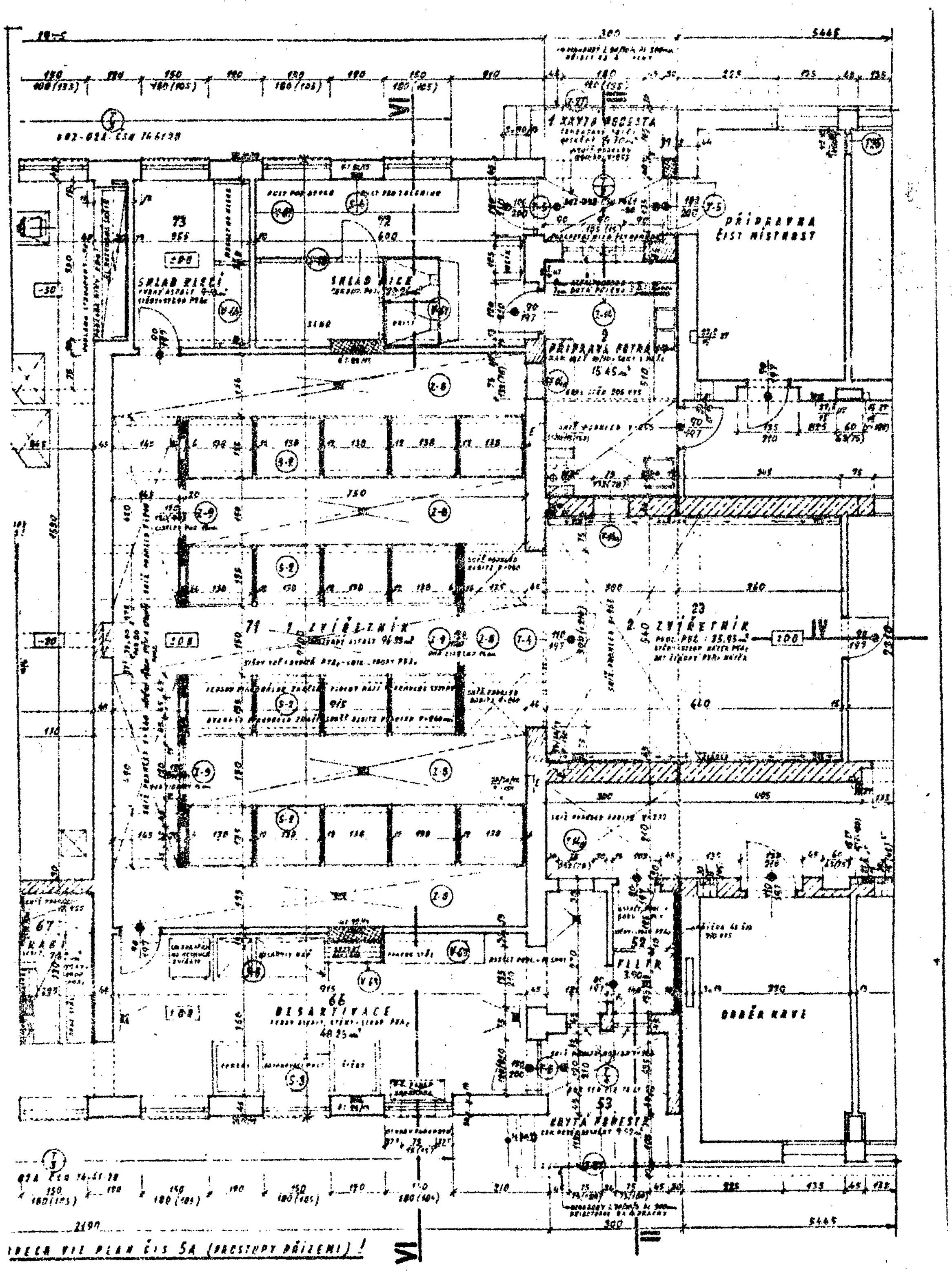
[Below is the key to the diagram.]

770 - dressing room
75 - engine room
74 - ventilating system engine room
73 - storage for cages
72 - storage for fodder
1, 53 - covered landing on top of stairs
2 - preparation of feed
23 - zoo
71 - zoo
726 - preparation room, cleaning room
590 - blood test
79 - boiler room
81 - coal storage
69 - water main
70, 80 - stairway
68 - decontamination
67 - laundry
66 - deactivation

F - For further passages through walls and ceilings refer to chart No. 5A (Main Floor Passages)

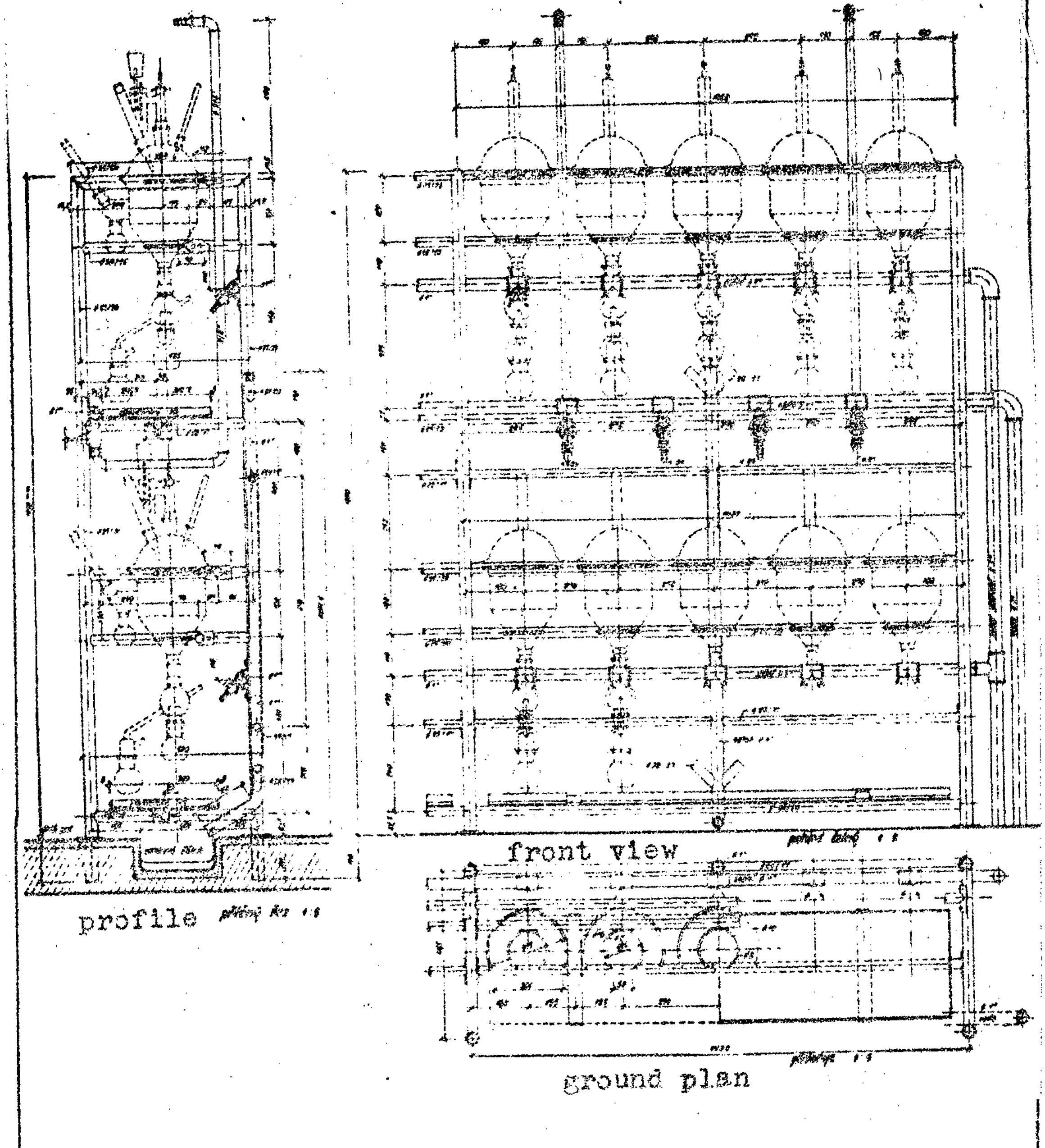


SKLADIŠTĚ
KOTELNA
STROJOVNA VZDUCHOTECHNIKY
81
79
IV
VII
DALŠÍ PROSTUPY VE ZDECH A STR

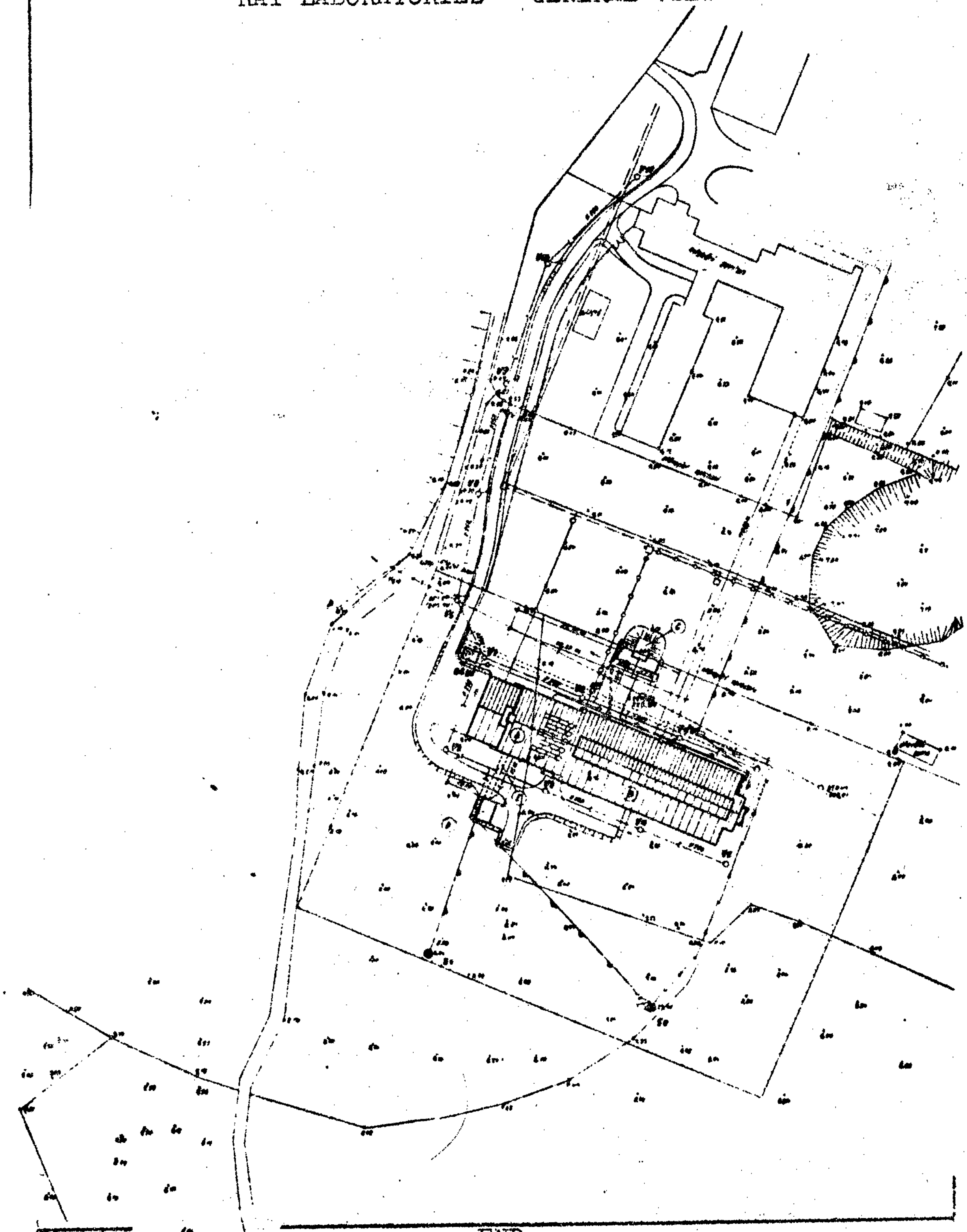


RADIOISOTOPIC LABORATORIES FOR THE FACULTY OF MEDICINE AT HRADEC KRALOVE

Stand for Metabolic Cages Housing Small Animals



RAI LABORATORIES - GENERAL VIEW



2076

END